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Depleted Uranium Test Range Fragment Reclamation

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This report summarizes the efforts of a two-phase program aimed at reclaiming depleted uranium (DU) alloy fragments generated from the testing of GAU-8 penetrators at Eglin Air Force Base, Florida. Phase I developed methods of separating, cleaning, and melting the DU fragments. Four separate melting and casting heats were made and evaluated. Excellent chemical quality was established and the casting yields were better than 97 percent. Phase II efforts manufactured 150 GAU-8 penetrators of acceptable quality from the material reclaimed in Phase I. Acceptable commercial products were also cast from the reclaimed DU alloy to

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ITEM 20. ABSTRACT (Concluded)

demonstrate an additional application for the material.

PREFACE

This program was conducted by Nuclear Metals, Inc. (NMI), 2229 Main Street, Concord, Massachusetts, 01742, under Contract Number F08635-82-C-0100 with the Air Force Armament Laboratory, Armament Division, Eglin Air Force Base, Florida 32542. Mark J. Walz and Charles Latham-Brown, Project Engineers, managed the program for NMI. The program manager for the Armament Laboratory was Don D. Harrison (DLV). The program was conducted during the period from November 1981 to June 1982.

The Public Affairs Office has reviewed this report, and it is releasable to the National Technical Information Service (NTIS), where it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

JOE A. FARMER
Chief, Environics Office

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OBJECTIVES AND SCOPE OF THE PROGRAM

1. OBJECTIVE OF THE PROGRAM

The objective of the program was to reclaim depleted uranium (DU) metal fragments generated from GAU-8 munitions testing. Recycling these fragments using existing manufacturing technology would supply the Air Force with a desirable option to waste disposal by land burial for these test range fragments. In addition, DU recovered from the deactivation of stored rounds that have exceeded their shelf-life would also become feasible in the future.

2. SCOPE OF THE PROGRAM

The program was structured as a two-phase effort. Phase I examined the feasibility of reclaiming test range fragments by vacuum induction remelting (VIR).

The technical direction of Phase II was highly dependent upon the results of Phase I. The material quality obtained in Phase I determined the methodology used in Phase II to manufacture GAU-8 penetrators from the reclaimed DU.

SECTION II

PROCESSING AND MANUFACTURING PROCEDURE

1. INTRODUCTION

The test range fragment processing and manufacturing procedure used for both phases of the effort is shown in Figure 1. These processing and manufacturing steps were used to obtain material for penetrator manufacturing and for the casting of industrial radiography shields.

2. SEPARATION PROCEDURE

a. DU Metal Separation From Test Range Contaminants

Test range fragments were shipped to the contractor from the Air Force Armament Laboratory, Eglin Air Force Base, Florida. The shipment included DU and aluminum fragments from the GAU-8 penetrator, sand and stones from the test range, and a variety of lesser contaminants.

The material had been removed from a sand-filled target butt used as a back stop during testing of GAU-8 penetrator rounds. Prior to removal of the contaminated sand from the target butt approximately 20,000 rounds had been fired into the sand. After removal the sand was sifted through a one-half inch mesh seive which removed the larger DU fragments, aluminum, and other debris. The sifted sand was replaced in the target butt and the material collected on the seive surface was placed in drums for shipment.

This material was again screened at the contractor's facility to remove the bulk of the sand and small stones. The isolated fragments were washed in water to allow for easier visual identification of aluminum fragments. The aluminum fragments were manually removed by the workers performing the processing.

b. DU Fragment Etch In Sodium Hydroxide (NaOH) and Water Rinse

All remaining fragments were etched in a 50 percent solution of NaOH to bright-etch any previously unidentifiable aluminum. Etching was followed by a water rinse to remove residual NaOH and to facilitate further handling, after which bright etched aluminum fragments were manually removed from the DU fragments.

c. Nitric Acid Pickle and Water Rinse

DU fragments were pickled in a 50 percent nitric acid solution for approximately 10 to 20 minutes and then rinsed in water. The pickling etched trapped sand from those DU fragments where penetrator-impact during test firing caused a fusing of the sand from the heat of friction. Removing the sand was critical to minimizing silicon contamination during remelting.

d. Drying the Fragments

DU fragments were dried utilizing a drying process developed by the contractor to facilitate DU machine-chip recycling. This specific process is

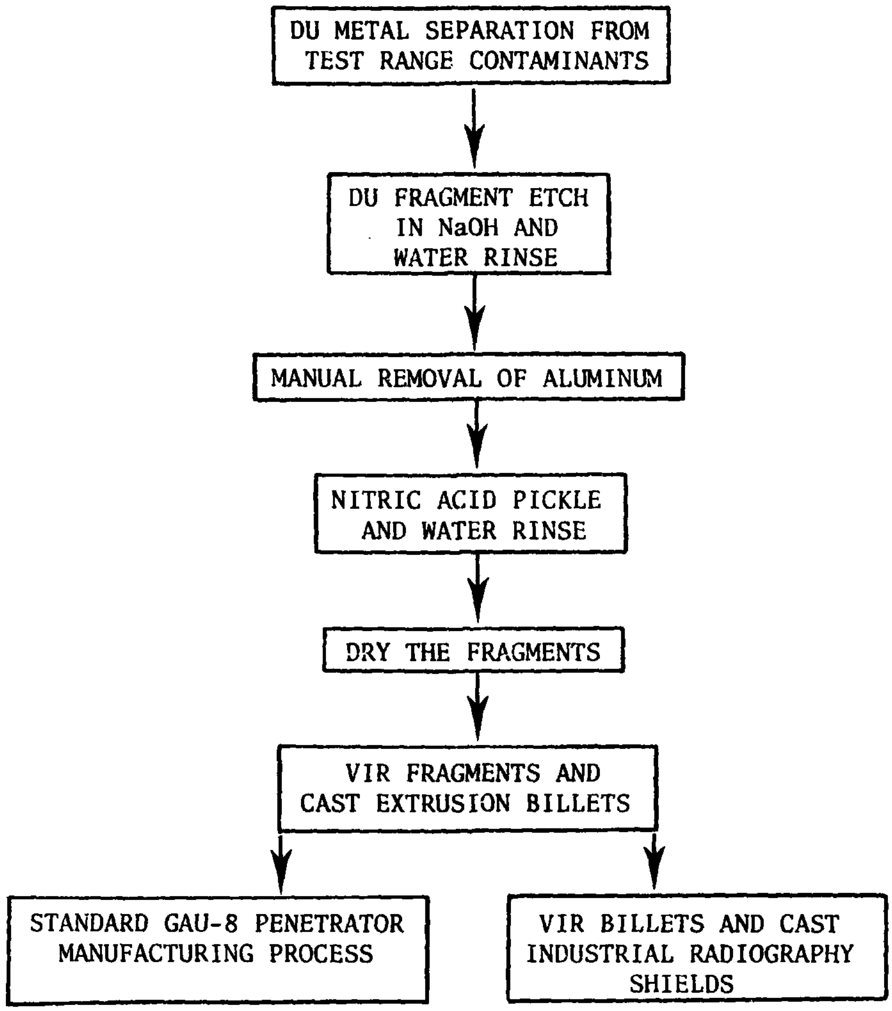

Figure 1. Fragment Processing and Manufacturing Flow Chart

being patented and will not be disclosed at this time. However, many other drying methods are suitable for drying fragments that would not be suitable for drying machine chips. The drying process chosen was used because of convenience and availability of processing equipment.

Thorough fragment drying was necessary in order to obtain adequate vacuum levels in the VIR furnaces.

e. Vacuum Induction Remelting Fragments and Casting Extrusion Billets

The DU fragments were consolidated utilizing VIR furnaces. These furnaces are typically used within this industry to melt the DU-3/4 Ti alloy.

Four casting heats were made with the recovered DU fragments. Extrusion billets measuring 4 1/2 inches in diameter by 20 inches in length (11.43 centimeter diameter by 50.80 centimeter length) were cast from these melt heats. The tip of one billet from each casting heat was removed for chemical analysis.

The melting furnace cycle was controlled to slowly bring the DU fragments up to 1350°C (2462°F). This temperature was held for 30 minutes before pouring the molten metal and casting the billets. Material yield from the three nominal 1800-pound (817 kilogram) melts was in excess of 97 percent. The fourth, a much smaller melt weighing 240 pounds (109 kilograms), had a casting yield of 83.7 percent.

3. MANUFACTURING FOR MILITARY USE

a. Standard GAU-8 Penetrator Manufacturing Process

The contractor employed its standard, and proprietary, GAU-8 penetrator manufacturing process to produce 50 penetrators from each of 3 different melting and casting heats. A total of 150 penetrators was fabricated and shipped to Air Force designated locations for evaluation beyond the scope of this program.

There were no adjustments needed to the standard manufacturing processing to compensate in any way for the unusual origin of the reclaimed metal.

b. Material Evaluation

Material evaluation was limited to chemical analysis and heat treating response as indicated by the Rockwell Hardness Scale (Rc). These are the standard quality assurance techniques employed in GAU-8 penetrator production to meet the specification shown in Table 1.

The chemical analyses of the various casting heats made in this program are shown in Table 2.

Many repetitive hardness measurements were taken to establish that the hardness requirements, set forth in the GAU-8 penetrator process specification, were obtained after heat treatment.

4. MANUFACTURING FOR INDUSTRIAL USE

Industrial radiography shields are commercial products that make use of the radioactive shielding properties of DU. These shields are typically used to shield higher radioactive isotopes for a number of radiography and medical treatment applications.

A shield casting was made with billet material, cast from test range fragments, to demonstrate the applicability of the reclaimed metal for commercial product applications. This approach was undertaken to demonstrate an additional application for the reclaimed DU in the event the reclaimed metal was unsuitable for reuse in penetrators.

TABLE 1. HONEYWELL GAU-8 PENETRATOR SPECIFICATIONS

CHEMICAL REQUIREMENTS		
ELEMENT	DESIRED LEVEL	MAXIMUM PERMISSIBLE LEVEL
TITANIUM	0.75 ± 0.10%	0.75 ± 0.10%
CARBON	200 PPM	300 PPM
HYDROGEN (H_2)	10 PPM	15 PPM
OXYGEN (O_2)	165 PPM	300 PPM
NICKEL	80 PPM	150 PPM
COPPER	65 PPM	65 PPM
SILICON	125 PPM	125 PPM
IRON	200 PPM	300 PPM
ALL OTHER	50 PPM	50 PPM
HARDNESS REQUIREMENTS		
HARDNESS RANGE: Rc 44-48		
NO INDIVIDUAL READING LESS THAN Rc 40 OR GREATER THAN Rc 52		

TABLE 2. CHEMICAL ANALYSIS AND CASTING YIELD DATA

MELT NO.	CHARGE WGT. Lbs. (Kg.)	CASTING YIELD %	NUMBER OF BILLETS CAST	CHEMISTRY (PPM)							COMMENTS
				C	Ti (%)	O2	Al	Si	Fe	Cu	
UX7194	1800 (817.2)	98.9	9	40	.73	--*	22	42	160	2	FRONT — EXTRUDED ROD LOCATIONS
				50	.74	--	22	39	160	3	MIDDLE — EXTRUDED ROD LOCATIONS
				50	.73	--	25	45	160	2	REAR — EXTRUDED ROD LOCATIONS
UX7292	1750 (794.5)	97.8	9	40	.75	--	19	81	89	6	FRONT — EXTRUDED ROD LOCATIONS
				40	.75	33	20	83	85	6	MIDDLE — EXTRUDED ROD LOCATIONS
				70	.74	--	21	75	86	5	REAR — EXTRUDED ROD LOCATIONS
UX7383	1750 (794.5)	97.4	9	40	.74	--	38	80	75	7	FRONT — EXTRUDED ROD LOCATIONS
				40	.75	27	38	85	77	6	MIDDLE — EXTRUDED ROD LOCATIONS
				50	.77	--	37	80	74	7	REAR — EXTRUDED ROD LOCATIONS
UX7404	596 (270.6)	83.7	4	--	--	--	--	--	--	-	
UX7547	240 (109.0)	94.4	-	--	--	--	--	--	--	-	RADIOGRAPHY SHIELDS CAST FROM UX7194 MATERIAL

NOTE: EXTRUDED ROD LOCATIONS FRONT, MIDDLE, AND REAR, CORRESPOND TO CASTING LOCATIONS BOTTOM, MIDDLE, AND TOP OF BILLET.

* DASHES INDICATE ANALYSES NOT PERFORMED

SECTION III

CONCLUSIONS

All program objectives were achieved with total success. A viable reclamation process for DU test range fragments can be developed from the basic techniques employed in this program.

The program has demonstrated the technical feasibility of obtaining excellent DU material quality by recovering test range fragments. This recovered material can be re-used for GAU-8 penetrator production or for commercial product applications.

The GAU-8 penetrators fabricated from several casting heats demonstrated reliability of the processing techniques employed. The program further demonstrates the feasibility of reclaiming the DU penetrators that would result from the deactivation of GAU-8 rounds which will one day be removed from the government's arsenals. Recycling disassembled penetrators will not have the severe technical problems associated with reclaiming metal from a mixture of test range fragments and assorted contaminants.

Improved procedures for the separation of DU penetrators and penetrator fragments from other waste components at the test range would facilitate the establishment of an effective recycling program for Eglin DU residue. Existing technology to perform this separation shall be integrated in order to assess its applicability.